DETAILED ACTION

Response to Arguments

Applicant's arguments with respect to claims 1-14 have been considered but are moot in view of the new ground(s) of rejection as explained hereunder.

Applicant has amended claims 1, 3, 4, 7, 13 and 14 by adding new limitations for example in claim 1, new limitations "have lengths", slot lengths" and "to at least a point between the first intermediate and peripheral portions have been added. Further, applicant has cancelled claims 2, 5, 6, 12 and added new claims 15-24.

Claims 1, 3, 4, 7-11 and 13-24 are now pending and active.

New reference (US 5,415,719 - Akimoto) when combined with Otsubo et al reads on amended claim 1 limitations. Accordingly claims 1, 7, 8, 13-15, 18-20 and 23 have been rejected under 35 USC 103 (a) as explained below. Balance claims 3, 4, 9-11, 16, 17, 21, 22 and 24 have also been rejected under 35 USC 103 (a) as explained below.

Applicant argument that Ishii et al do not disclose an area where slot length is maintained is moot in view of new grounds of rejection of claim 1 as explained below.

Applicant further argues that Otsubo does not disclose increasing or decreasing the slot lengths from a central portion to a first intermediate portion and then maintaining the slot lengths in another area of the antenna extending from the first intermediate portion to a peripheral portion. Also Otsubo does not show an antenna area between a first intermediate portion and a peripheral portion that has the same slot lengths. Further, although the text of Otsubo mentions double or triple structures, there is a complete lack of specificity on the detail of the slot lengths.

Examiner responds that Akimoto teaches a quadruple structure of concentric slots wherein by controlling the number and spacing of slit 14a, the plasma density distribution can be controlled. Thus, Otsubo in view of Akimoto teach that microwave power radiated from the slots is dependent upon radial location of slots, and to obtain uniform power output in double/triple structure of slots, parameters like slot position, length of slots, thickness of slot plate and width of slots etc are controlled (optimized) {as result effective variable}, and by relatively controlling the length of inner and outer slots, uniformity of processing can be improved. Thus it would be obvious in view of teaching of Otsubo et al and Akimoto to optimize relative slot length of inner and outer slots in the radial regions from the central portion towards a peripheral portion through first and second intermediate regions, to control microwave distribution as per process limitations, like to improve uniformity of plasma processing. Thus, Otsubo in view of Akimoto teach all limitations of claim 1 as explained below. Further, balance claims have also been rejected as explained below.

Claim Rejections - 35 USC § 103

The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to

which said subject matter pertains. Patentability shall not be negatived by the manner in which the invention was made.

This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

Claims 1, 7, 8, 13-15, 18-20 are 23 are rejected under 35 U.S.C. 103(a) as being unpatentable over Otsubo et al (US 4,985,109) in view of Akimoto (US 5,415,719).

Regarding Claims 1, 13, 14: Otsubo et al teach a plasma apparatus/method comprising a processing vessel 1 with a table 7 for placing an object 12 thereon, and a slot antenna 5 with plurality of slots 5a (located in a central portion and at an intermediate portion). Otsubo et al further teach that by varying the slot position, slot length and width of slot the microwave power radiated from the slots can be controlled. Otsubo et al also teach that by controlling the length of inside slot with respect to length of outside slot uniformity of plasma processing can be controlled. Otsubo et al additionally teach that antenna slot structure can also comprise triple structure (that is slots located at a central portion, a first intermediate portion and towards a peripheral portion), in a radial direction on the antenna surface. It would be obvious to optimize

length of slot (as a result effective variable) to control the microwave power output from the inner and outer slots and control uniformity of plasma processing (e.g. Figs. 1, 2, 8, 9 and col. 12, line 53 to col. 13, line 23).

Otsubo et al do not disclose details of triple structure of slots (that is, slots located in a central portion, intermediate portion and peripheral portions) and also do not teach a plurality of slots formed in an antenna surface of said slot antenna have lengths that increase monotonously in a radial direction of the antenna surface from a central portion of the antenna surface until a first intermediate portion on the way to a peripheral portion, and maintain slot lengths obtained at the first intermediate portion from the first intermediate portion toward the peripheral portion to at least a point between the first intermediate and peripheral portions.

Akimoto teaches a microwave plasma apparatus with a slot antenna 14 having plural concentric slots 14a (quadruple structure of concentric slots) and wherein by controlling the number and spacing of slit 14a, the plasma density distribution can be controlled. Akimoto further teaches that when the slits 14a of the slot antenna 14 are concentric circles the area of slots (that is, length and width of slots) in different radial regions of antenna can be controlled (optimized) such that the difference in electric field between the center portion and the peripheral portion can be suppressed, to thereby generate a more uniform plasma density. Akimoto also teaches that the distance and number of the slots 14a can be also controlled (optimized) to obtain desired electric field distribution (e.g. Figs. 5, 9 and col. 4, line 20 to col. 5, line 15). It would be obvious to control (optimize) the length of slots (as a result effective variable) in the central, intermediate and peripheral regions on the antenna surface as per teaching of Akimoto in the apparatus of Otsubo et al to control microwave power output from the slots in the central,

intermediate and peripheral regions on the antenna surface, to improve uniformity of plasma processing over the wafer surface.

Therefore it would have been obvious to one of ordinary skills in the art at the time of the invention to optimize the length of slots in the central, intermediate and peripheral regions on the antenna surface as per teaching of Akimoto in the apparatus of Otsubo et al to control microwave power output from the slots in the central, intermediate and peripheral regions on the antenna surface and improve uniformity of plasma processing over the wafer surface.

In this connection courts have ruled:

It is well settled that determination of optimum values of cause effective variables such as these process parameters is within the skill of one practicing in the art. *In re Boesch*, 205 USPQ 215 (CCPA 1980).

Regarding Claims 7, 8: Otsubo et al in view of Akimoto teach all limitations of the claim (as already explained under claim 1 above) including that the relative length of inner and outer slots (in a radial direction) is optimized (as a result effective variable) to obtain desired microwave distribution and obtain improved uniformity of plasma processing (e.g. Otsubo et al – col. 12, line 53 to col. 13, line 23 and Akimoto – Fig. 9). It would be obvious to optimize the slot lengths over the antenna surface including slot lengths in the central, first intermediate, second intermediate and the peripheral regions, as per teachings of Otsubo et al in view of Akimoto to obtain desired microwave field distribution, as per process limitations, like improving uniformity of plasma processing.

Regarding Claims 15, 23: Otsubo et al in view of Akimoto teach all limitations of the claim including a processing vessel 1 with a table 7 for placing an object 12 thereon, and a slot antenna 5 with plurality of slots 5a. Otsubo et al further teach that by varying the slot position, slot length, width of slot the microwave power radiated from the slots can be controlled. Otsubo et al also teach that by controlling the length of inside slot with respect to length of outside slot, uniformity of plasma processing can be controlled. Otsubo et al additionally teach that antenna slot structure can also comprise triple structure (that is slots located at a central portion, a first intermediate portion and towards a peripheral portion), in a radial direction on the antenna surface. It would be obvious to optimize relative length of inner and outer slots (as a result effective variable) to control the microwave power output from the slots and control uniformity of plasma processing (e.g. Figs. 1, 2, 8, 9 and col. 12, line 53 to col. 13, line 23).

Further, Akimoto teaches a microwave plasma apparatus with a slot antenna 14 having plural concentric slots 14a (quadruple structure of concentric slots) and wherein by controlling the number and spacing of slit 14a, the plasma density distribution can be controlled. Akimoto further teaches that when the slits 14a of the slot antenna 14 are concentric circles the area of slots in different radial regions of antenna can be controlled (optimized) {as a result effective variable} such that the difference in electric field between the center portion and the peripheral portion can be suppressed, to thereby generate a more uniform plasma density. Akimoto also teach (Fig. 9) that slot length of outer slot can decrease with respect to inner slot (e.g. Figs. 5, 9 and col. 4, line 20 to col. 5, line 15).

In this connection courts have ruled:

It is well settled that determination of optimum values of cause effective variables such as these process parameters is within the skill of one practicing in the art. *In re Boesch*, 205 USPQ 215 (CCPA 1980).

Regarding Claims 18-20: Otsubo et al in view of Akimoto teach all limitations of the claim (as already explained under claim 15 above) including that the relative slot length of inner and outer slots is optimized (as a result effective variable) from a central portion to a first intermediate portion, then to a second intermediate portion and on the way towards a peripheral portion, to obtain desired microwave distribution as per process limitations, like improving uniformity of plasma processing (e.g. Otsubo et al – col. 12, line 53 to col. 13, line 23, and Akimoto – Fig. 9).

Claims 3, 4, 9, 10 are rejected under 35 U.S.C. 103(a) as being unpatentable over Otsubo et al (US 4,985,109) in view of Akimoto (US 5,415,719) as applied to claims 1, 7, 8, 13-15, 18-20, 22 and further in view of Ishii et al (US 5,698,036).

Regarding Claim 3: Otsubo et al in view of Akimoto teach all limitations of the claim including length of slots increases from the central region towards the periphery of slot antenna (e.g. Otsubo- Figs. 8, 9 and Akimoto – Fig. 9).

Otsubo et al in view of Akimoto do not teach length of slot is

L </= lambda.g/2

or

(N/2 + 1/4) x lambda.g </=L </= (N + 1) x lambda.g/2 (N is a natural number) where lambda.g is a wavelength of an electromagnetic field in said slot antenna.

Ishii et al teach a plasma apparatus with a slot antenna 44 wherein the length of slots L increases from L1 in the central region to L2 in a peripheral region. Ishii et al also teach that length of each slot is about half of lambga.g (e.g. Figs. 1 -3, and col. 5, line 50 to col. 6, line 60).

Therefore it would have been obvious to one of ordinary skills in the art at the time of the invention to keep the length of slot nearly equal to half of geode wavelength as taught by Ishii et al in the apparatus of Otsubo et al in view of Akimoto to obtain efficient transmission of microwaves through the slots.

Regarding Claim 4: Ishii et al teach that length of slot is half the guide wavelength to obtain efficient transmission of microwaves through the slots. Ishii et al also teach that length of outer slot 60B is longer than length of inner slot 60A (Fig. 3). Further, it would be obvious to control (optimize) the relative length of inner and outer slots, in view of teaching of Otsubo et al and Akimoto such that the electric field distribution can be controlled and thus uniformity of plasma processing can be improved.

Regarding Claims 9, 10: Otsubo et al in view of Akimoto and Ishii et al teach (as already explained above under claim 1) including that length of slots is optimized (including decreases – Fig. 9 of Akimoto) depending upon electric field distribution and is generally at a maximum lambda.g/2. It would be obvious to optimize the lengths of slots over the antenna surface between the inner most slot to a slot at a first intermediate portion, from a slot at a first intermediate portion till a slot at the second intermediate portion and from a slot at the second intermediate portion until the peripheral portion as per teaching of Otsubo et al in view of

Akimoto, to obtain desired microwave distribution as per process limitations, like improving uniformity of plasma processing.

Claims 11, 16, 17, 21, 22 are rejected under 35 U.S.C. 103(a) as being unpatentable over Otsubo et al (US 4,985,109) in view of Akimoto (US 5,415,719) as applied to claims 1, 7, 8, 13-15, 18-20, 23 and further in view of Watanabe et al (US 6,158,383).

Regarding Claims 11, 16, 17, 21, 22: Otsubo et al in view of Akimoto teach all limitations of the claim including that lengths of slots is generally lambda.g/2 (maximum) {that is, L >/= N *lambda.g/2, for N = 1} and the same is optimized in a radial direction on the antenna surface, as per desired microwave distribution.

Otsubo et al in view of Akimoto do not teach that length of slot L satisfies the relation,

L < / = (N/2 + ¼) * lambda.g (that is, N < / = 0.75 * lmbda.g for N = 1).

Watanabe et al teach a plasma apparatus comprising a processing chamber 1 with slot antenna 7 having slots 8, and where slot length is kept larger than lambda.g/2, (which meets the claim limitation) depending upon thickness of conductor plate used for slot antenna, to enable propagation of electric field in the axial direction (e.g. Fig. 7 and col. 6, lines 25-50). It would be obvious to optimize the relative lengths of inner and outer slot in the central, first intermediate, second intermediate and peripheral portions, in view of teachings of Otsubo et al in view of Akimoto to obtain required microwave distribution as per process limitations, like improving uniformity of plasma processing.

Therefore it would have been obvious to one of ordinary skills in the art at the time of the invention to optimize slot length relative to radial distance from the second intermediate portion

till the peripheral portion as taught by Watanabe et al in the apparatus of Otsubo et al in view of Akimoto to obtain desired electrical field distribution as per as per process limitations like uniformity of plasma processing.

Claims 24 are rejected under 35 U.S.C. 103(a) as being unpatentable over Otsubo et al (US patent No. 4,985,109) in view of Akimoto (US 5,415,719) and Ishii et al (JP 2002-050615, which has an English equivalent, US 2004/0045674).

Regarding Claim 24: Otsubo et al in view of Akimoto and Ishii et al teach all limitations of the claim (as already explained above under claim 15 above) including that relative slot lengths of inner and outer slots are optimized to obtain desired microwave electric field distribution, as per process limitations like improving uniformity of plasma processing.

Otsubo et al in view of Akimoto do not explicitly teach radiation coefficient of slots are decreased monotonously from the second intermediate portion until the peripheral portion.

Ishii et al teach a plasma apparatus/method (e.g. Figs. 2, 6-8) comprising a processing chamber 11 with a slot antenna 31 with plurality of slots 36. Ishii et al further teach that length L1 of slots 36 increases as the slots are located farther away from the central portion towards periphery in a radial direction on the center of antenna surface. Ishii et al further teach that as the microwave power is gradually radiated from the slots towards the periphery due to increase in slot length from the central portion towards an intermediate portion, the power of microwave in the waveguide decreases, that is, radiation coefficient (ratio of power radiated from the slot to the

power in the waveguide) increases from the central portion towards the periphery as the slot length increases.

Though Ishii et al do not explicitly teach that the slot length obtained at the first intermediate portion are maintained from the first intermediate portion of the antenna surface until a second intermediate portion on the way to the peripheral portion in the radial direction of the antenna surface, and the radiation coefficients are decreased monotonously from the second intermediate portion until the peripheral portion, it would be obvious to optimize the relative slot length of inner and outer slots, as per teaching of Otsubo et al in view of Akimoto as per process limitations, e.g. to improve uniformity of plasma processing, such that the power of microwave in the waveguide increases, that is, radiation coefficient (ratio of power radiated from the slot to the power in the waveguide) decreases from the second intermediate portion until the peripheral portion.

Therefore it would have been obvious to one of ordinary skills in the art at the time of the invention to optimize the relative slot length of inner and outer slots, such that the radiation coefficient decreases from the second intermediate portion until the peripheral portion as per teaching of Ishii et al in the apparatus of Otsubo et al in view of Akimoto to obtain desired microwave distribution as per process limitations like to improve uniformity of plasma processing.

In this connection courts have ruled:

It is well settled that determination of optimum values of cause effective variables such as these process parameters is within the skill of one practicing in the art. *In re Boesch*, 205 USPQ 215 (CCPA 1980).

Conclusion

Applicant's amendment necessitated the new ground(s) of rejection presented in this Office action. Accordingly, **THIS ACTION IS MADE FINAL**. See MPEP § 706.07(a). Applicant is reminded of the extension of time policy as set forth in 37 CFR 1.136(a).

A shortened statutory period for reply to this final action is set to expire THREE MONTHS from the mailing date of this action. In the event a first reply is filed within TWO MONTHS of the mailing date of this final action and the advisory action is not mailed until after the end of the THREE-MONTH shortened statutory period, then the shortened statutory period will expire on the date the advisory action is mailed, and any extension fee pursuant to 37 CFR 1.136(a) will be calculated from the mailing date of the advisory action. In no event, however, will the statutory period for reply expire later than SIX MONTHS from the date of this final action.

Any inquiry concerning this communication or earlier communications from the examiner should be directed to RAKESH K. DHINGRA whose telephone number is (571)272-5959. The examiner can normally be reached on 8:30 -6:00 (Monday - Friday).

If attempts to reach the examiner by telephone are unsuccessful, the examiner’s supervisor, Parviz Hassanzadeh can be reached on (571)-272-1435. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/Rakesh K Dhingra/
Examiner, Art Unit 1792

/K. M./
Primary Examiner, Art Unit 1792